MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2021/2022

PPH0036 – MODERN PHYSICS & THERMODYNAMICS

(All sections / Groups)

5 OCTOBER 2022
9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages (excluding physical constant and formula list) with 6 Questions only.

2. Attempt **ALL** questions. The distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

4. All necessary workings **MUST** be shown.

Question 1 [8 marks]

(a) A progressive wave, $D = 5\sin\left(\frac{\pi}{15}x - 100\pi t\right)$ where D and x in cm and t in s, propagates from left to right. It is reflected from a wall to produce a standing wave.

(i) Write an equation for

(I) the wave reflected from the wall, [1 mark]

(II) the standing wave [1 mark]

(ii) Determine the distance between two consecutive nodes. [2 marks]

(b) A narrow column of 20°C air is found to have standing waves at frequencies of 390 Hz, 520 Hz and 650 Hz and none in between these.

(i) Is this an open-open tube or an open-closed tube? Explain. [2 marks]

(ii) How long is the tube? [2 marks]

Question 2 [5 marks]

(a) Two in-phase speakers 3.0 m apart in a plane are emitting 686 Hz soundwaves. If a person is standing at a point 4.0 m in front of one of the speakers, will he hear loud sound or no sound? [2 marks]

(b)

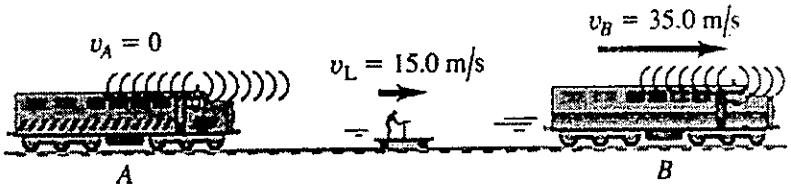

Figure Q2(b)

Two train whistles, A and B, each have a frequency of 392 Hz. A is stationary and B is moving toward the right (away from A) at a speed of 35.0 m/s. A listener is between the two whistles and is moving toward the right with a speed of 15.0 m/s (Fig. Q2(b)). No wind is blowing. Calculate,

(i) the frequency from A as heard by the listener [1 mark]

(ii) the frequency from B as heard by the listener [1 mark]

(iii) the beat frequency detected by the listener [1 mark]

Continued...

Question 3 [12 marks]

(a)

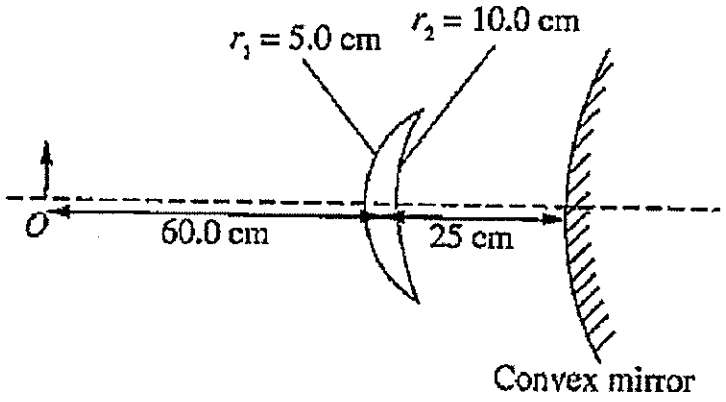

Figure Q3(a)

The arrangement of a lens and a convex mirror is shown in Fig. Q3(a). The radii of curvatures of the lens r_1 and r_2 are 5.0 cm and 10.0 cm respectively. The refractive index of the lens is 1.5. The convex mirror of focal length 10.0 cm is placed 25 cm at the back of the lens. An object O is placed 60.0 cm in front of the lens. Determine the

(i) focal length of the lens, [3 marks]

(ii) position of the image formed by the lens, [2 marks]

(iii) final position of the image formed by the lens and the convex mirror. [3 marks]

(b)

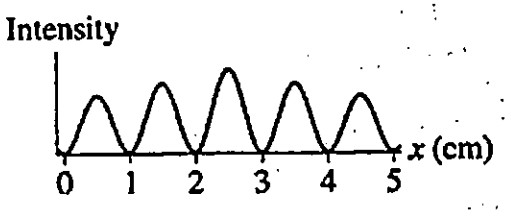

Figure Q3(b)

Figure Q3(b) shows the light intensity on a screen 2.5 m behind an aperture. The aperture is illuminated with light of wavelength 600 nm.

(i) Is the aperture a single slit or double slits? Explain. [2 marks]

(ii) If the aperture is a single slit, what is its width? If it is a double slit, what is the spacing between the slits? [2 marks]

Continued...

Question 4 [7 marks]

(a)

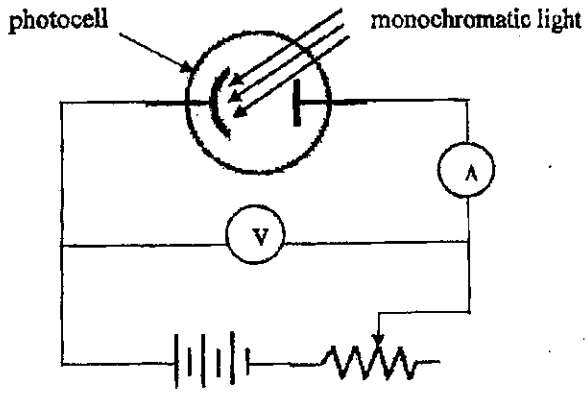

Figure Q4(a)

Figure Q4(a) shows a photocell connected to a battery, ammeter, voltmeter and rheostat. The photocell is exposed to a monochromatic light of wavelength 275 nm. Initially, the reading of voltmeter is zero and the reading of ammeter is 5 nA. The rheostat is adjusted until the ammeter reading reaches zero and the voltmeter reading -0.3 V.

(i) Why current is detected by the ammeter although the set-up appears to be an incomplete circuit? [1 mark]

(ii) Sketch a graph of current flow in the circuit against the voltage across the photocell. [2 marks]

(iii) Calculate the work function of the photocell. [2 marks]

(b)

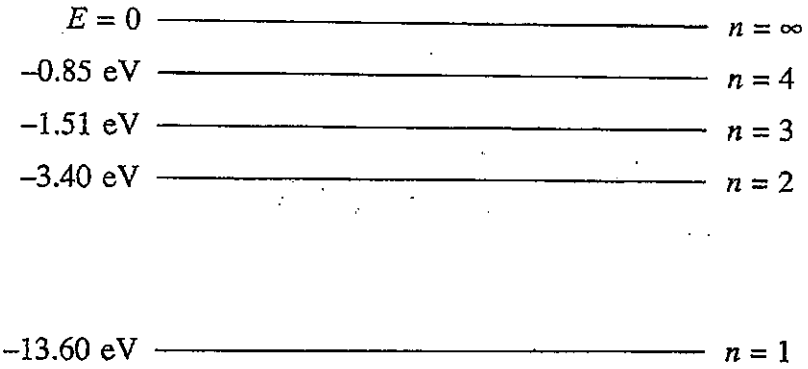

Figure Q4(b)

Figure Q4(b) shows the energy levels of a hydrogen atom at various states. What would happen to the photons of energies 12.0 eV and 10.2 eV when they pass through a stable state atomic hydrogen vapour? [2 marks]

Continued...

Question 5 [7 marks]

(a)

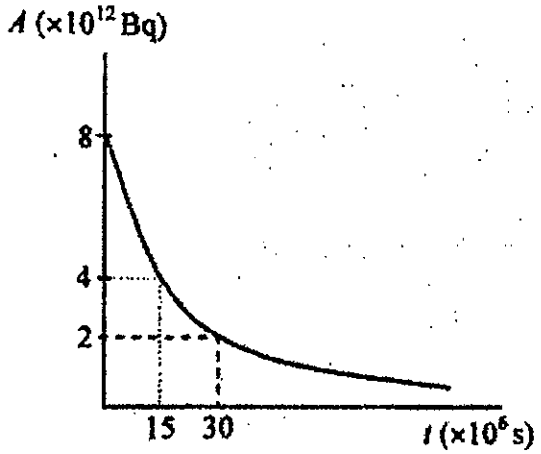

Figure Q5(a)

Figure Q5(a) shows the decay curve of a radioactive sample. Determine

(i) the half-life of the radioactive sample [1 mark]

(ii) the time for the activity of the radioactive sample to decay until 10% of the initial activity. [3 marks]

(b) An isotope of Polonium $^{218}_{84}$Po decays by emitting an alpha particle and energy to transform into daughter nucleus of Lead Pb-214.
[Atomic mass of Po-218 = 218.008965 u, atomic mass of Pb-214 = 213.999798 u and mass of alpha particle = 4.002603u]

(i) Write the complete reaction for the decay. [1 mark]

(ii) Determine the energy released by the decay. [2 marks]

Continued...

Question 6 [11 marks]

(a)

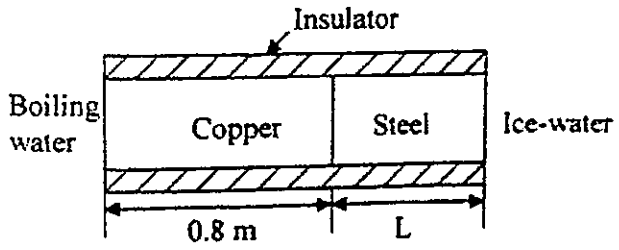

Figure Q6(a)

Figure Q6(a) shows composite rod of copper and steel, a perfectly insulated is in contact with boiling water at one end and with an ice-water mixture at the other end. The lengths of the copper and steel are 0.8 m and L respectively. The cross-sectional area of both rods are 1.5 cm^2. The temperature of the copper-steel junction is 56°C when steady state is achieved. Given: thermal conductivities of copper = 385 $Wm^{-1}K^{-1}$ and of steel = 50.2 $Wm^{-1}K^{-1}$. Calculate the value of L. [3 marks]

(b) How much heat is needed to melt 26.50 kg of silver that is initially at 25°C? Given that the melting point of silver is 961°C, the specific heat of silver is 230 J/kg°C and the heat of fusion of silver is 88 kJ/kg. [3 marks]

(c) A 0.8 mole of ideal gas is filled in a 1.3 m^3 container. It is heated from 30 kPa to 37 kPa without any changes to its volume. Then by keeping the temperature at 32°C, the gas is expanded to twice its original volume.

(i) Sketch and label a P-V diagram of the thermodynamics processes on a same axes. [3 marks]

(ii) Calculate the total work done in the whole process. [2 marks]

End of Page

Physical Constants

Acceleration due to gravity	g	=	$9.8\ \text{m s}^{-2}$
Speed of Sound in Air	v	=	$343\ \text{m s}^{-1}$
Speed of light in vacuum	c	=	$3 \times 10^{8}\ \text{m s}^{-1}$
Threshold of hearing	I_o	=	$1.0 \times 10^{-12}\ \text{W m}^{-2}$
Coulomb constant	k	=	$9.0 \times 10^{9}\ \text{N m}^{2}\ \text{C}^{-2}$
Electronic charge	e	=	$1.602 \times 10^{-19}\ \text{C}$
Electron mass	m_e	=	$9.11 \times 10^{-31}\ \text{kg}$
Proton mass	m_p	=	$1.6726 \times 10^{-27}\ \text{kg}$
Neutron mass	m_n	=	$1.6749 \times 10^{-27}\ \text{kg}$
Refractive index of air/vacuum	n	=	1.0
Wein's displacement constant		=	$0.2898 \times 10^{-2}\ \text{m.K}$
Planck's constant	h	=	$6.626 \times 10^{-34}\ \text{J. s}$
Rydberg constant	R_H	=	$1.097 \times 10^{7}\ \text{m}^{-1}$
Avogadro's Number	N_A	=	$6.02 \times 10^{23}\ \text{mol}^{-1}$
Unified atomic mass unit	1 u	=	$1.66 \times 10^{-27}\ \text{kg}$
	1 eV	=	$1.602 \times 10^{-19}\ \text{J}$
Threshold of intensity of hearing	I_o	=	$1.0 \times 10^{-12}\ \text{Wm}^{-2}$
Stefan-Boltzmann constant	σ	=	$5.67 \times 10^{-8}\ \text{J s}^{-1}.\text{m}^{-2}.\text{K}^{-4}$
Universal gas constant	R	=	$8.31\ \text{J mol}^{-1}\ .\ \text{K}^{-1}$
Boltzmann's constant	κ	=	$1.38 \times 10^{-23}\ \text{J K}^{-1}$
	1 atm	=	$1.013 \times 10^{5}\ \text{Pa}$

The energy equivalent of the atomic mass unit is 931.494 MeV

Formula List

$\sin\theta_1 + \sin\theta_2 = 2\sin ½(\theta_1 + \theta_2)\cos ½(\theta_1 - \theta_2)$

$\cos\theta_1 + \cos\theta_2 = 2\cos ½(\theta_1 + \theta_2)\cos ½(\theta_1 - \theta_2)$

$\sin\left(\theta + \frac{\pi}{2}\right) = \cos\theta$

$\sin\theta \approx \tan\theta \approx \theta$ *rad* for small angle

$D(x, t) = D_M \sin(kx \pm \omega t \pm \phi)$

$v = \sqrt{\frac{F_T}{\mu}}$ $\quad$ $v = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}}$

$\lambda_n = \frac{2}{n}L$ $\quad$ $f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$

$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ $\quad$ $\frac{1}{f} = (n-1)\left\{\frac{1}{R_1} + \frac{1}{R_2}\right\}$

$d\sin\theta = m\lambda$ $\quad$ $d\sin\theta = \left(m \pm \frac{1}{2}\right)\lambda$

$\lambda_m . T = 0.2898 \times 10^{-2}$ $\quad$ $I(\lambda, T) = \frac{2\pi c k_B T}{\lambda^4}$

$E_n = -\frac{mk^2e^4}{2\hbar^2}\left(\frac{1}{n^2}\right)$ $\quad$ $r_n = \frac{\hbar^2}{mke^2}n^2$ $\quad$ $L = mvr_n = n\hbar$

$\frac{1}{\lambda} = R_H\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$ $\quad$ $\frac{1}{\lambda} = \frac{mk^2 Z^2 e^4}{4\pi c\hbar^3}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$ $\quad$ $\lambda = \frac{h}{p}$

$R = R_0 e^{-\lambda t}$ $\quad$ $\lambda = \frac{\ln 2}{T_{\frac{1}{2}}}$ $\quad$ $Q = (M_X - M_Y - M_a)c^2$

$pV = nRT$ $\quad$ $k = \frac{R}{N_A}$

$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta L}$ $\quad$ $\frac{\Delta Q}{\Delta t} = e\sigma AT^4$ $\quad$ $\frac{\Delta Q}{\Delta t} = IeA\cos\theta$

$\overline{KE} = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT$ $\quad$ $U = \frac{3}{2}nRT$

$Q = \Delta U + W$ $\quad$ $W = \int dW = \int_{V_i}^{V_f} P dV$